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EVOLUTION OF BOTULISM

IV. Epidemiological Prerequisites for Acquiring Resistance to Botulism by the Ancestors of Contemporary Man.

[Following is the translation of an article by P. N. Burgasov and S. N. Runyantsev, published in the Russian-language periodical Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii (Journal of Microbiology, Epidemiology, and Immunobiology), No 2, 1968, pages 83-87. It was submitted on 22 April 1967.]

The possibility of the genetic selection of resistant individuals and the formation of species resistance to certain etiological agents of botulism during the various stages of existence of Homo sapiens or his animal ancestors could have been conditioned by a number of circumstances. It must be recalled that nutrition hygiene in the XIXth and even the XXth centuries did not ensure the possibility for the prevention of mass cases of botulism with a high mortality rate in civilized countries up to the introduction of special legislation which took into consideration new data about this disease. Assuming that hygienic measures of an elementary nature, which may have certain value in the prophylaxis of botulism, to a certain measure limited contacts by man with the causative agent during the entire period of civilization (several thousands of years), we, in examining the modern picture of the epidemiology of botulism, cannot ignore the earlier period of organic history, when contacts by the ancestors of modern man with nature had different regularities. Considering the specifics of the epidemic process and the level of its intensity which would be necessary for it to become a factor of natural selection based on the criterion of resistance to a given pathogenic agent, it is expedient to begin the investigation of the problem with those remote times when the ancestors of modern man, having ecological ties with nature, were found in complete dependence on it.

Of primary importance in this plan is information concerning types of nutrition of remote and more recent ancestors of modern man in accordance with existing concepts about the process of anthropogenesis. Keeping in mind that the natural resistance of man to individual etiological agents of botulism is a heriditarily strengthened trait and that man could have inherited it from his animal ancestors (including from Primates which are common for the contemporary order), it is necessary to examine anthropological materials concerning the earliest and latest stages in the evolution of Hominids. On the basis of vast materials available anthropologists have compiled a basic hypothetical arrangement which reflects the modern concept on the sequence of formation of the characteristic attributes of Homo sapiens.

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The widest acknowledgement among anthropologists (Roginskiy, 1947; Yakimov, 1951; Ginzburg, 1963) has been gained by the system of evolution of Hominids in which the following conditional periods are distinguished: 1) the period of Australopithecus, the predecessor of man; 2) the period of Pithecanthropus; 3) the period of Neanderthal man; 4) the period of Neo-anthropoid, man of the contemporary physical type.

The earliest Primates - the predecessors of Australopithecus, as paleontological findings testify, were particularly plant-eating animals, similar to modern man-like monkeys which also feed primarily on fruits, leaves, buds, and young plant shoots. The conditions of using these plant substances as food practically excluded the possibility of the epizootically significant contact of these animals with Cl. botulinum, since the latter do not multiply and do not form toxin in such substrates.

The beginning of the first period of evolution of Hominids was preceded by the transition of the direct predecessor of Australopithecus from an arboreal life in the tropical forest and herbivorous food to a terrestrial residence under conditions of the forest steppe and even in semiarid lands. As food they begain to make use of completely new plants and parts of them, and, which is particularly important, insects and small animals. Contemporary lowly organized monkeys under natural conditions feed mainly on plant products (fruits, bulbs, roots, tubers, seeds, leaves, etc.). Together with this many of them have a tendency to be euryphages. In particular the Macacus eats insects, eggs of birds, young nestlings, etc.

The use of small rodents as food was the first step to the eating of the dead bodies of larger animals, and then to hunting for animals with the help of various natural weapons (Yakimov, 1951). Australopithecus is viewed as a fossil anthropoid, already quite close to man in a morphological and phylogenetic respect (Roginskiy, 1947; Semenov, 1966) and corresponding to the stage of "monkeys taking sticks." They walked on two legs and used various natural objects (sticks, rocks, bone fragments, etc.) as weapons for self-defense and attack. These were euryphages, attacking not only small but comparatively large animals. The structure of the teeth of Australopithecus testifies to their capacity to feed both on animal and plant food. Thus vegetarian habits were abandoned by the anthropoid ancestors of Hominids already in the pre-human stage of anthropogenesis. This circumstance - the transition from primarily herbivorous nourishment to primarily carnivorous - was an exceptionally important moment for the subsequent direction in the evolution of the ancestors of man. In works by Engels on anthropogenesis he stresses more than once that meat had a very important significance for the process of humanizing of the monkey. It was a factor for the progressive development of the brain. The use of meat as food proved itself the "new important step on the path of transformation into man." 1

1. F. Engels, Dialectics of Nature, Izd., p 136.

The adaptation of animals to feeding on various food permitted them the possibility of wider settlement and made it possible for them to settle in areas which were very diverse based on climatic conditions. Roginskiy (1947) suggests that euryphagy of the ancient Hominids was one of the adaptations which made it possible for them to settle vast territories. Together with other factors the vast areal of ancient Hominids and their numbers conditioned the intensive process of a large number of diverse biological adaptations, which subsequently permitted the most progressive line to reach the highest level of progress.

The transition to the new type of feeding and the use of meat together with this brought the Hominids into ecological bonds with species of pathogenic bacteria which were new to them and to the development of new infectious diseases, the mechanisms of transmission of which were connected with ecological interrelations in the animal world. In this phase of interrelations with nature the ancestors of man began to penetrate incomparably more intimately than previously and there was very active contact with the animal world which populated the earth. This circumstance, in the opinion of Gromashevskiy (1962), conditioned the possibility for the development of a number of diseases which were zoonotic in origin and new to man. Thanks to the vast economical activity of man zoonoses up to the present time comprise more than half of the known infectious diseases of man.

Among the pathogenic bacteria which are capable of developing in meat, Cl. botulinum is found on an unapproachable level on the strength of the lethal effect of the toxins produced by it. Therefore the change in ecological conditions which accompanied the development of contact with such an extreme factor was an additional circumstance influencing the evolution of Hominids. Having obtained tremendous advantages, thanks to euryphagy, in the process of subsequent development, they were able to overcome unfavorable influences connected with it just as other euryphages. The mechanisms which guarantee the survival of species under similar circumstances (from the point of view of the individual) were unusually severe. Paleontological data makes it possible to think (Roginskiy, 1951) that species of previously existing terrestrial primates which were close to Australopithecus and which were not able to adjust to the changing conditions of life disappeared without leaving descendents. However, other species which possessed a high degree of ecological plasticity could occupy the proper place among the direct ancestors of man.

Australopithecus and similar Hominids, which were very intimately bound with the world surrounding them and dependent on it, were completely subjected to the action of biological laws of natural selection and the struggle for survival. This is more prevalent in subsequent stages of evolution, including primitive man (Zhirnov, 1963).

Simian-like man, who inherited the capacity for euryphagy from his direct predecessors - the Australopithecus, was already able to distinguish crude weapons, and this promoted an increase in the specific proportion of meat in his food ration. Numerous findings of bones of animals together with weapons which were the labor of simian-like people show that hunting for animals was the main labor activity of man already in the initial period of his existence. Prey was used as food in an untreated form. In particular Pithecanthropus still was not able to make use of fire (Yakimov, 1951). Sinanthropus, who lived 700,000-600,000 years ago and who were already aware of fire, and even the more highly developed Neanderthal often used raw meat as food. Fire was used unsystematically in the preparation of food and from case to case. There is information that ancient people stored reserves of untreated meat (Borisovskiy, 1950). The idea of heat treatment of food may have emerged after the eating of carcasses of animals which had perished during forest or steppe fires. However, such a position can hardly have a significant influence on the epidemiological importance of sarcophagy. Even the later development of more "ideal" practices and habits in the preparation of meat products were insufficient to prevent outbreaks of botulism. During this period and later there weren't even the rudiments of hygienic requirements for the processing and storage of food.

From the point of view of natural selection based on the feature of resistance to botulism there is also great importance in an analysis of the following facts. Primitive man constantly experienced shortages of meat. This in particular served as the reason for the development of cannibalism (Yakimov, 1951). Cannibalism among Synanthropes and Neanderthal is testified to by numerous paleo-anthropological findings. Cannibalism was widespread also in the earlier stages of anthropogenesis. Important information on the nature of feeding of ancient man may be recovered from eyewitness accounts of the life of people who not long ago were still found of a low level of social development. Based on the evidence of Darwin the finding of a rotting corpse of a whale on the beach was a real holiday for fire cultivators. Under a similar situation Australoids remained around this carrion for a number of days and ate until they became satieted, until they became sick (Lebbok, 1876). The fire cultivators ate rotten fish with a great appetite. They buried large pieces of whale meat in the sand, creating reserves for time of hunger. The custom of eating half rotten meat from whales was also known among the Eskimos of Greenland; up until now this habit is the cause of outbreaks of botulism among them (Dolman, 1960). The Hottentots consumed dishes consisting of half-raw and half-rotten meat (Lebbok, 1876).

The unreliable methods which primitive man used for acquiring food made partial hunger unavoidable and led to the use of poor quality products as food (from the point of view of modern hygiene).

This led to a high mortality rate, in particular from various types of epidemics. The intensity of natural selection of those adapted to the existing conditions of life is testified to by the fact that 55% of the Neanderthals died before they were 20 years old. They still preserved in their way of life and feeding many survivals of "animal" existence (Borisovskiy, 1950). Ancient man who lived on the coast of Denmark in the beginning of the Neolithic ate foxes, wolves, and other predators indiscriminately. The sole domestic animal (the dog) was also used as food (Lebbok, 1876).

The life of primitive man was hard and full of all possible dangers. In a primitive way he could oppose the mighty forces of nature only with his biological qualities, in particular an expressed capacity for adaptation to unfavorable conditions. Nevertheless in the beginning of anthropogenesis vast spaces were settled by ancient Pithecanthropus. Man had to contend with a tremendous number of unfavorable and extreme factors along the way until he reached his contemporary state. Thanks to labor, adaptability, and development of the ability to think man gradually came out from under the influence of the surrounding nature and his subsequent evolution took place without the dominating influence of the latter.

The cited data testify that the possibilities for the ancestors of man to take part in a biological cycle which is characteristic for Cl. botulinum and the formation of natural immunity were no lesser than for other euryphages. The chronology of change in the ecology of Hominids makes it possible to date the onset of the development of natural resistance, for example, to type D botulism by the stage of Australopithecus. Apparently this process could have lasted with sufficient intensity even to more recent time when primitive man was still subjected to the action of the laws of natural selection. The effect of the factors considered in conformity with ecological peculiarities were hardly disproportionate in a geographical aspect. It is apparent that along with the development of industry and the strengthening of social organization it gradually weakened. It is considered (Reginskiy, 1948) that the sharp weakening of the influence of natural selection on man in connection with successes in the public organization of labor can be dated to orin'yakskoye [Aurignacian ?] time. This is testified to by the almost complete absence of changes in the main physical features of man along with the tremendous increase in culture during this time. However, the effect of natural selection based on the feature of resistance to disease apparently lasted later than this period since its cessation is connected to a considerable degree with the successes of medical science, and these belong to comparatively recent time.

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